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Navigation Lock and Dam Inspection and Emergency Repairs Workshop

ERDC Vicksburg, Mississippi

Concrete Condition Survey Methods in the Rock Island District

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18-20 April 2006

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The concrete deterioration is a functional issue

- The concrete deterioration is more of an issue of operability of lock and associated appurtenances.
- Operability issues
  - Lock staff safety
    - Smooth walking surfaces free of debris
  - Tow crew safety issues
    - Falling pieces of concrete
    - Protruding Armor.
    - Un-usable ladders
  - Damage to gates, floating mooring bits and appurtenances
  - Damage to tows

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Safety

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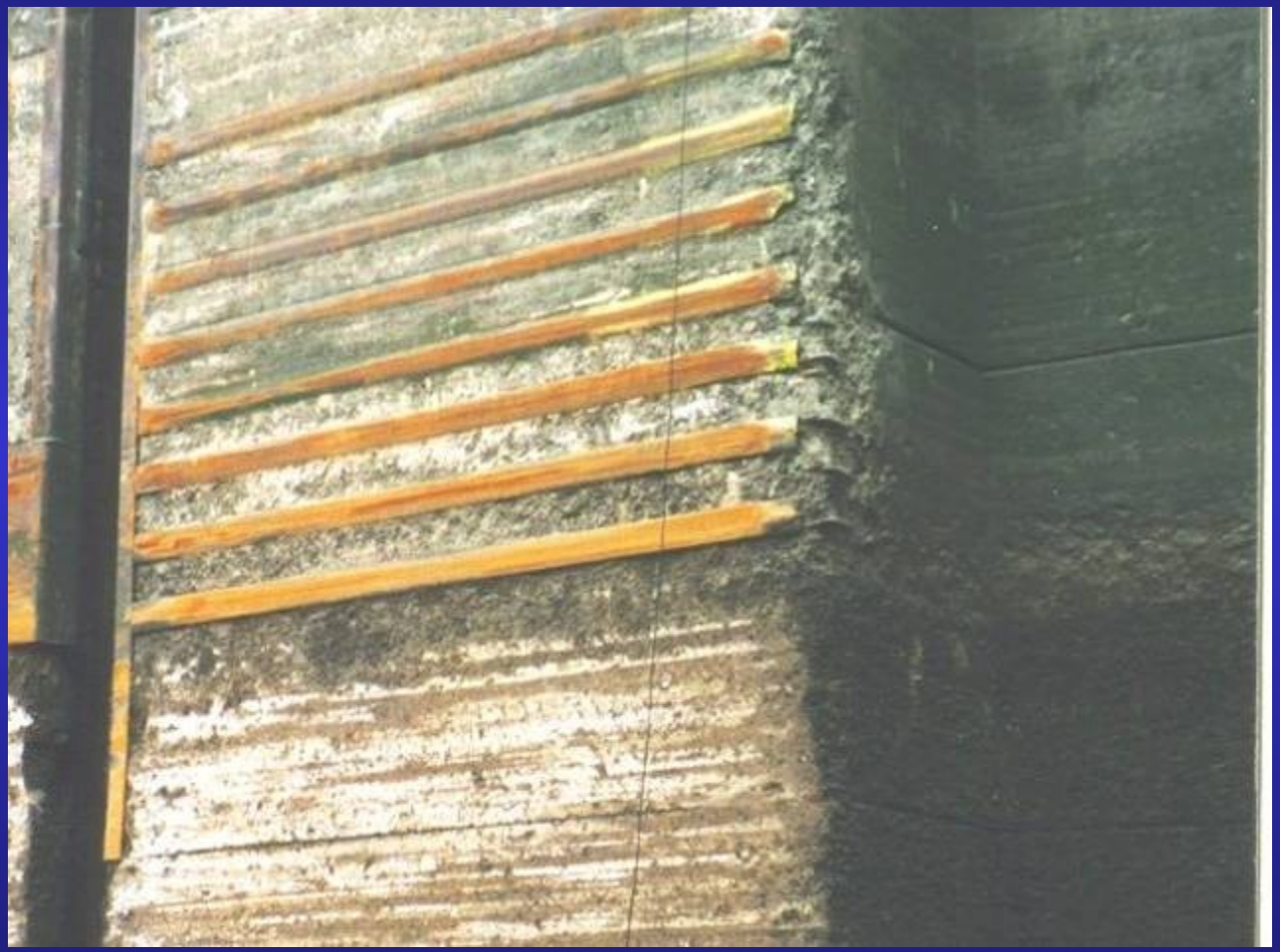
Damage to tows



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Concrete reliability

- Concrete deterioration causes topical damage to the locks which contribute to the inoperability of the lock appurtenances which reduces lock functionality. This is not captured in the current reliability models.

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The concrete is expensive

- The concrete work accounts for ½ of the construction of typical rehab projects.
  - The cost is too great to be handled by normal O & M funds. Hence the need for Major Rehab funding to complete this work.

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Concrete Condition Report

- **Concrete Investigation Methods**
  - **Review of structure historical records**
  - **Detailed examination of the structure**
  - **Laboratory investigation of samples.**

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History review

- Look at the age and construction of the structure.
- Materials used in construction
  - Cement type
  - Aggregate types and sources
    - Mineralogy
  - Mix proportions
- Construction test results

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Concrete condition survey

- **In accordance with:**
  - **EM 1110-2-2002 “Evaluation and Repair of Concrete Structures”**
  - **ACI 201.1 “Guide for Making a Condition Survey of Concrete in Service”**
- **These standard documents provide terminology in which to describe distress and deterioration of concrete. The documents also provide information on the mechanisms of certain distresses. Based on the symptoms we can diagnose different problems.**

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ACI 201.1R
EM 1110-2-2002

- **Provides definitions of distress types**
  - **Pattern cracking – Fine openings on concrete surfaces in the form of a pattern; resulting from a decrease in volume of the material near the surface , or increase in volume of the material below the surface, or both**

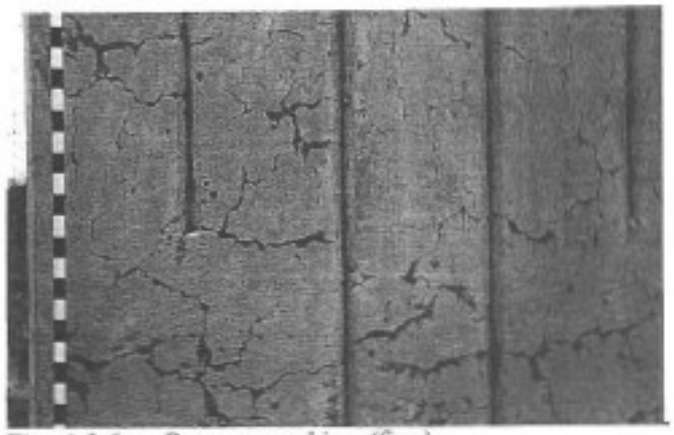

Fig. A.1.6a—Pattern cracking (fine)

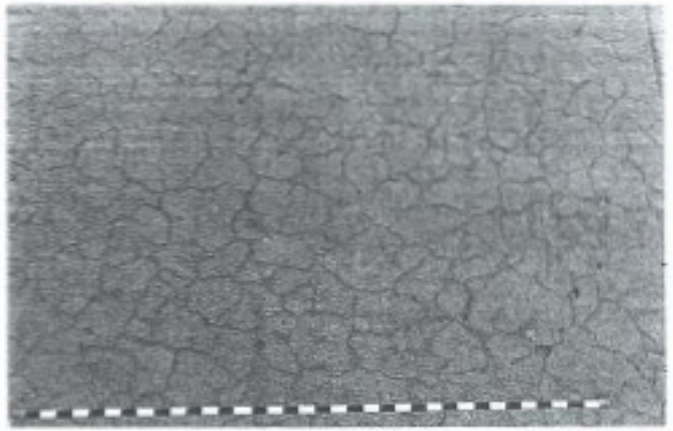

Fig. A.1.6b—Pattern cracking (medium)

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ACI 201.1R

EM 1110-2-2002

- Also provides definitions on severity.
- Scaling – Local flaking or peeling away of near surface portion of hardened concrete or mortar; also of a layer from metal
  - Scaling Light - Loss of surface mortar without exposure of course aggregate.
  - Scaling Medium – Loss of surface mortar 5 to 10 mm in depth and exposure of the course aggregate.
  - Scaling Severe – Loss of surface mortar 5 to 10 mm in depth with some loss of mortar surrounding aggregate particles 10 to 20 mm in depth
  - Scaling, Very Severe – Loss of course aggregate and particles as well as mortar, generally to depth greater than 20 mm in depth

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ACI 201.1R
EM 1110-2-2002

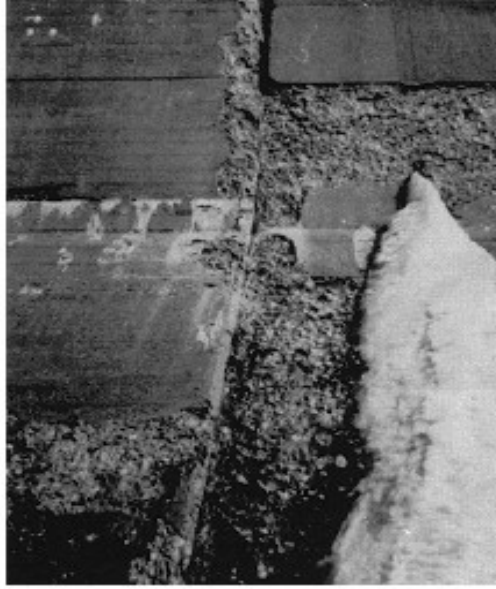

Figure 2-19. Very severe scaling

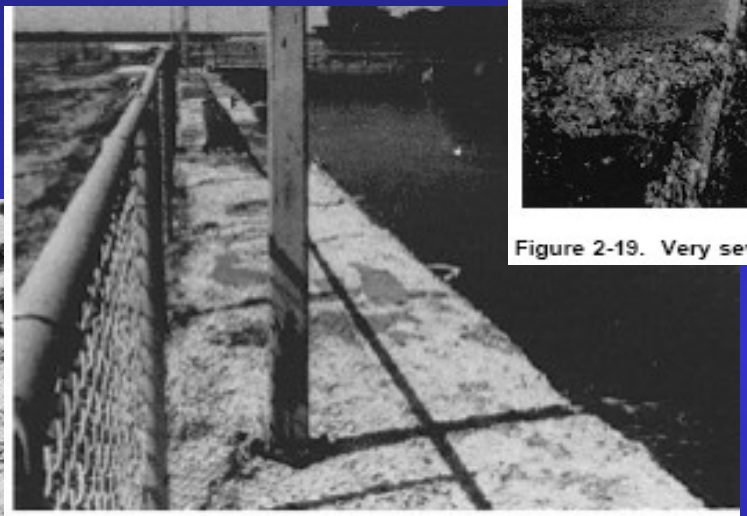

Figure 2-18. Severe scaling

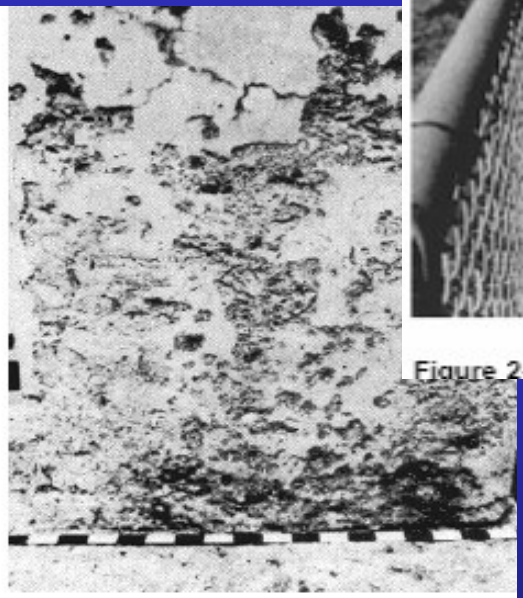

Figure 2-17. Medium scaling

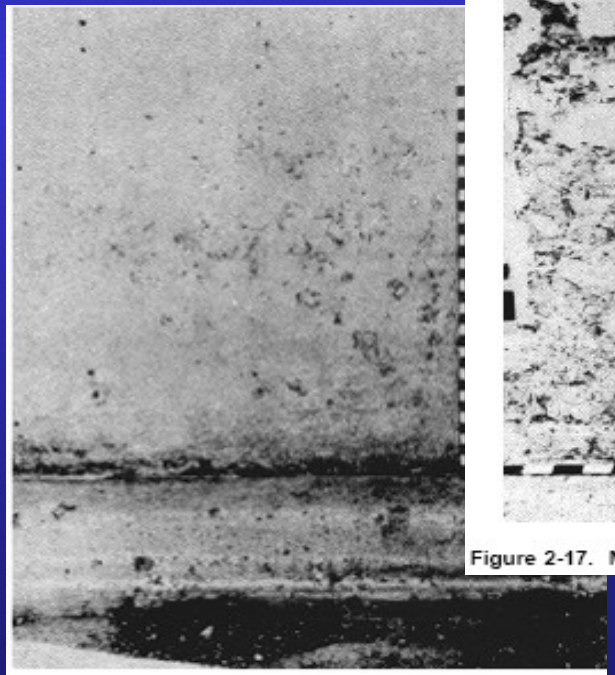

Figure 2-16. Light scaling

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EM 1110-2-2002

- **Chapter 3 provides information on many causes and distresses in concrete.**

- (4) Alkali-silica reaction.
  - (a) Mechanism. Some aggregates containing silica that is soluble in highly alkaline solutions may react to form a solid no expansive calcium-alkali-silica complex or an alkali-silica complex which can imbibe considerable amounts of water and then expand, disrupting the concrete. Additional details may be found in EM 1110-2-2000.
  - (b) Symptoms. Visual examination of those concrete structures that are affected will generally show map or pattern cracking and a general appearance that indicates that the concrete is swelling (Figure 2-6). Petrographic examination may be used to confirm the presence of alkali-silica reaction.
  - (c) Prevention. In general, the best prevention is to avoid using aggregates that are known or suspected to be reactive or to use a cement containing less than 0.60 percent alkalies (percent Na20 + (0.658) percent K20). Appendix D of EM 1110-2-2000 prescribes procedures for testing aggregates for reactivity and for minimizing the effects when reactive aggregates must be used.

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Concrete Condition Survey

- For lock chamber 2-3 people spend about a week at the site.
  - Visually examine and sound surfaces with a steel hammer all surfaces at the lock
  - Map distresses identified
  - Photo log each monolith
  - Obtain concrete cores
- 2-3 weeks to Assemble field notes, photos, etc.
- About 1 month to send and receive petrography results

Drawing with Distresses Mapped

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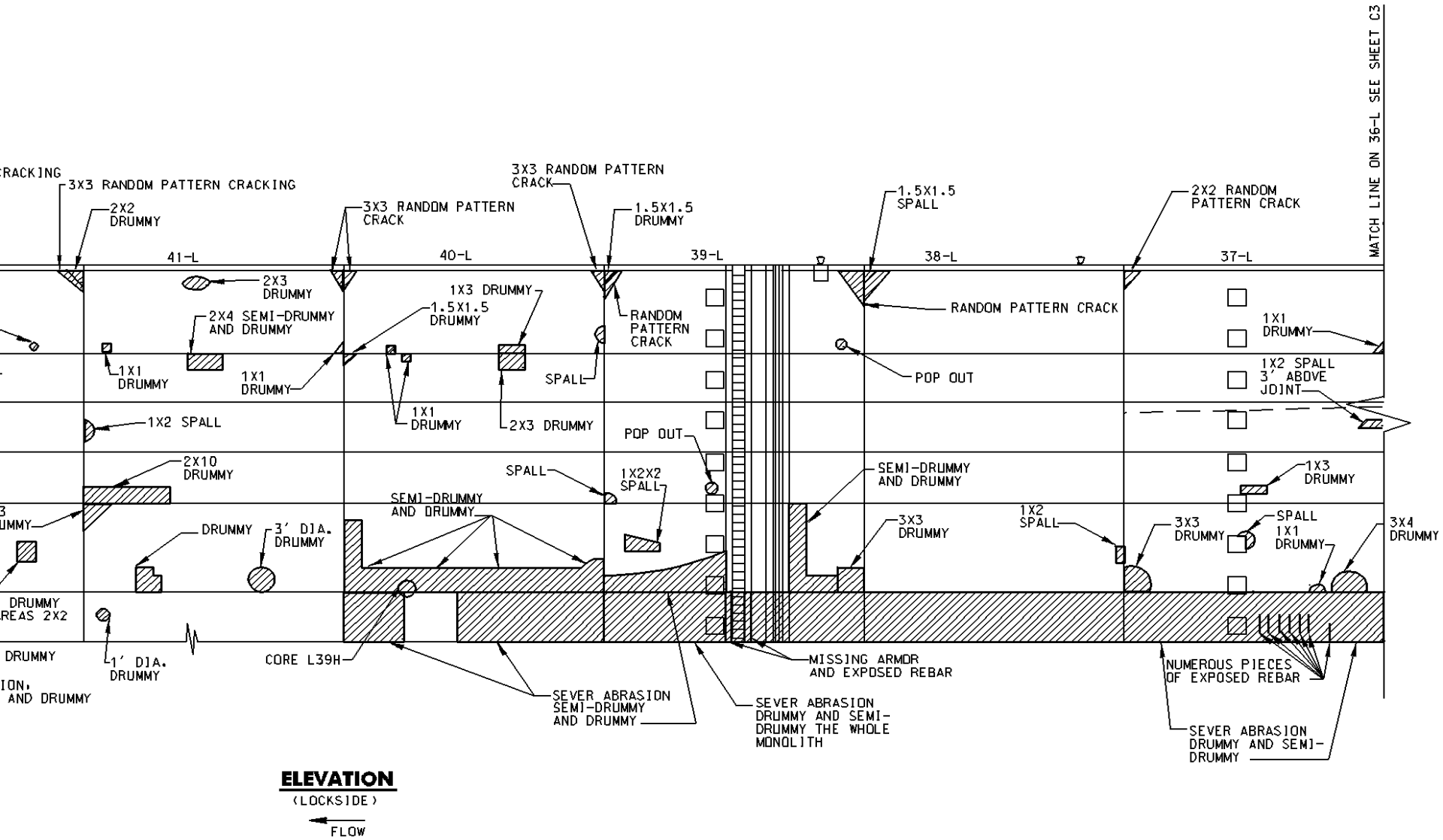
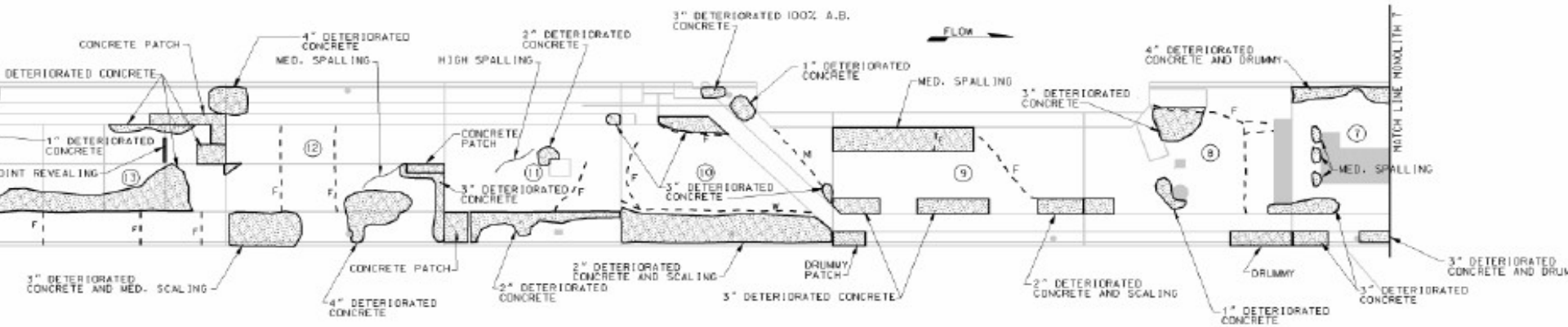
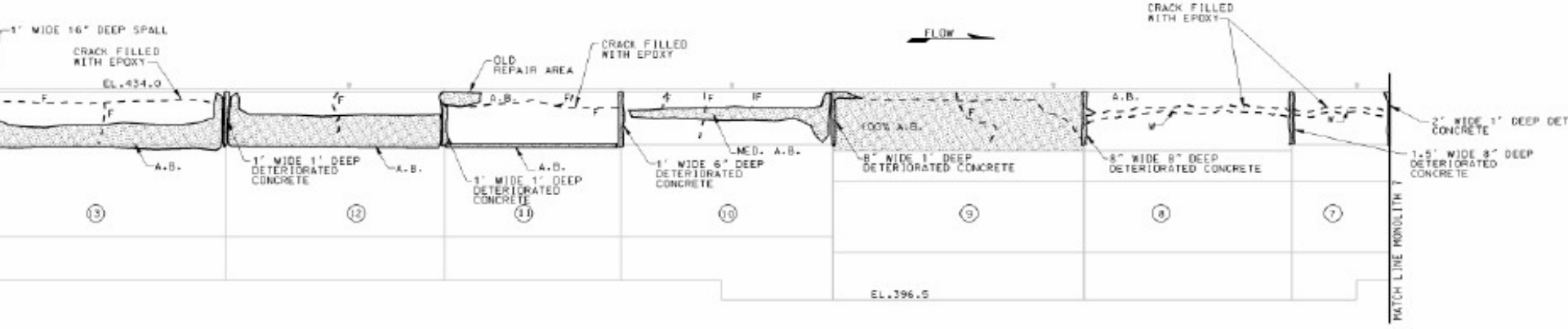


LEGEND:

- E — FINE CRACK (< 1 MM)
- M — MEDIUM CRACK (1- 2 MM)
- W — WIDE CRACK (> 2 MM)
- A.B. — ABRASIVE DAMAGE
- 100% A.B. — 100 PERCENT ABRASIVE AREA
- ● 120M — CORE BORING LOCATION
- DETERIORATED CONCRETE, ABRASIVE DAMAGE, DRUMMY, SPALLING, AND SCALING
- (24) — MONOLITH NUMBER
- EL. — ELEVATION
- EXISTING EMBEDDED METAL STRUC
- EXISTING BUILDING



PLAN-INTERMEDIATE WALL(LOCK SIDE)



ELEVATION-INTERMEDIATE WALL(LOCK SIDE)

B C D E F G H

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Photo-logged Each Monolith

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Intermediate Wall Monolith 8 (1985)

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Intermediate Wall Monolith 8 (2001)

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Typical Distresses present at Locks and Da

- Impact and Abrasion Damage
- Concrete De-lamination (Drummy Concrete)
- Pattern Cracking and Efflorescence

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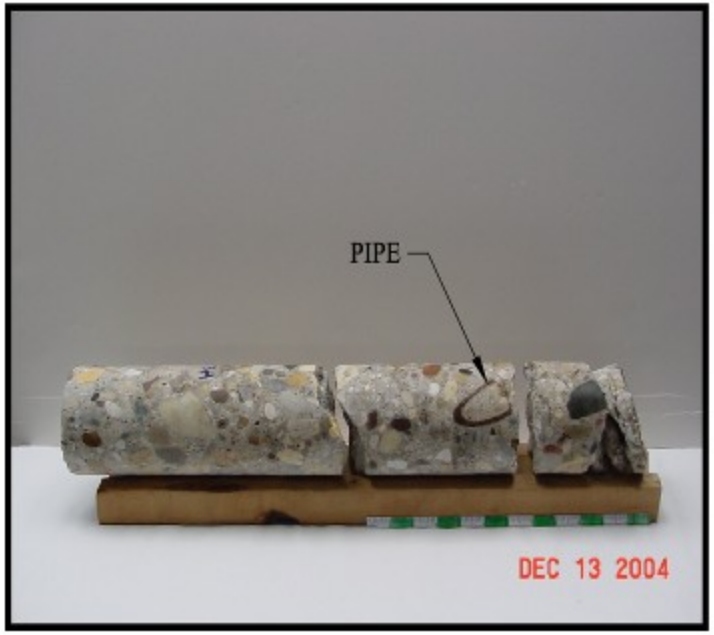
Obtaining Cores

DRILLING LOG	INSTALLATION: CEMVR-ED-G	PROJECT: LaGrange Lock Concrete Condition Survey
CORE NO.: L-13-H		DRILL DESIGNATION: Truco
LOCATION: Landwall on the horizontal surface of Monolith 13, 2' from Monolith joints 13 and 14, 5'-3" from top of wall..		TOTAL DEPTH OF HOLE: 1.85'
DIRECTION OF CORE: Horizontal		DATE OF DRILLING: Summer 2001
SIZE AND TYPE OF BIT: 4" diameter, inside length of 14.5", thin wall.		NAME OF DRILLER: George Millar

DEPTH (ft)	LEGEND	DESCRIPTION	REMARKS
0.00		Freeze-thaw damage. Breaks are through and around coarse aggregates.	
0.50		End section of a Ferris metal pipe of unknown origin.	
1.00		Broken to remove core. Break is through the coarse aggregate.	L-13-H Avg. Length: 6.5 in. Avg. Diameter: 4.0 in. Load: 94,000 lbs. Unit Weight: 151.0 pcf Str. Cor. Factor: 0.97 Comp. Str.: 7,256 psi
1.50		Broken to remove core. Break is through the coarse aggregate.	
2.00			
2.50		General: Coarse aggregates are natural gravels predominantly composed of a mixture of round to sub-round carbonate sedimentary rock particles with some igneous and metamorphic rock types. The fine aggregate is composed mostly of angular to sub-round quartz sand with carbonated rock particles. The maximum aggregate is two inches. The paste is hard and dense.	
3.00			
3.50			



US Army Corps of Engineers Rock Island District

Revisions

U.S. ARMY CORPS OF ENGINEERS ROCK ISLAND, ILLINOIS

Designed by: EAH
Drawn by: TPD
Checked by: GAH
Approved by: MES
Date: 25 JAN 2005
Scale: AS SHOWN
Drawing Number: 1906

ILLINOIS WATERWAY LaGRANGE LOCK AND DAM CONCRETE CONDITION SURVEY

CONCRETE CORE L-13-H

C-1

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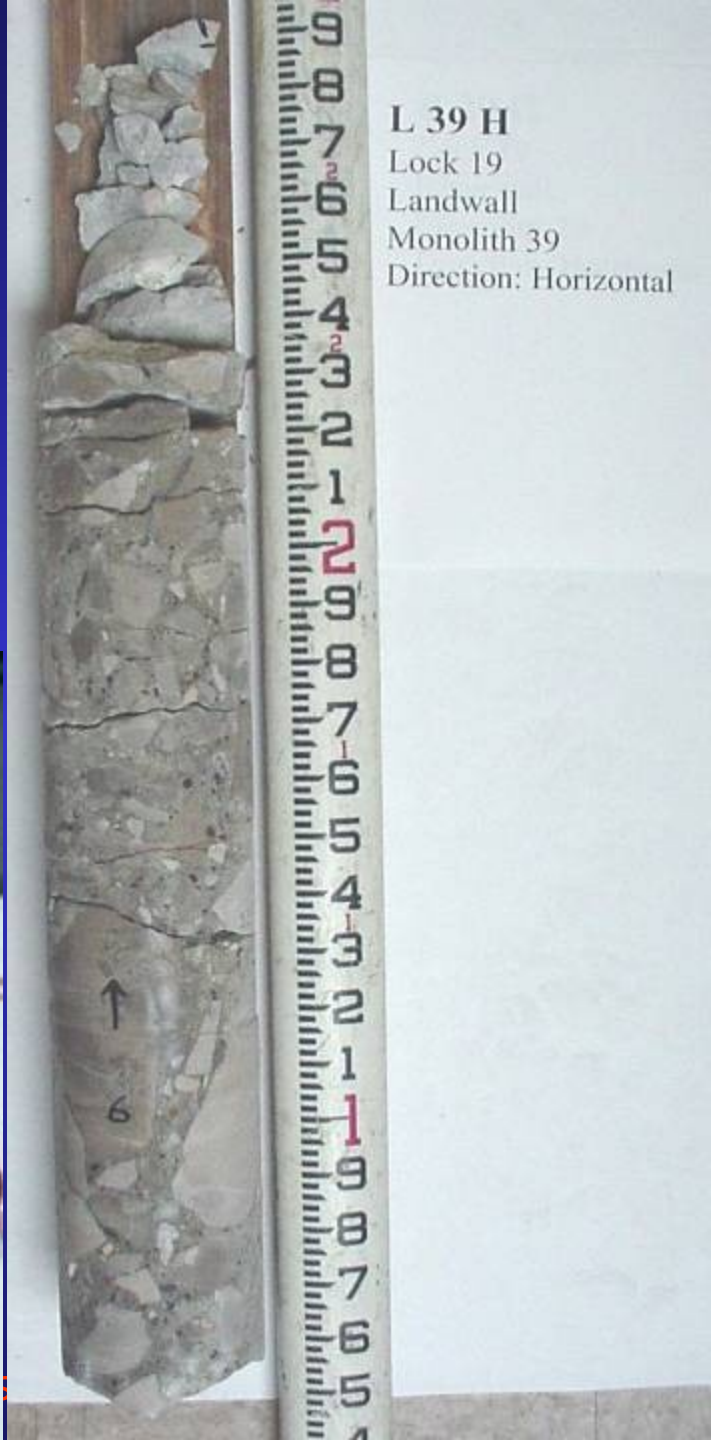
Cores

- Showed visible distress decreasing in severity with depth.
- Depth of deterioration
- Depth of PH degradation.



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Lab Testing

- **CEMVR**
  - Visual examination and Logging
  - Compressive Testing (For intact cores)
  - Depth of carbonation
  - Check for presence are air entrainment bubbles
- **Petrographic Analysis (WES)**
  - To help determine reasons for distresses found as part of the survey
  - Check for air entrainment, deleterious reactions.

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Petrographic Examination

- **Microscopic Examination**
- Allow us to gain qualitative understanding of the microstructure and chemical make up of the concrete.
  - Give insights to mineral composition of the concrete
  - Allows us to understanding the mechanisms of deterioration
- American Society for Testing and Materials, C 856-95, Standard Practice for Petrographic Examination of Hardened Concrete, 1995.

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Petrographic Analysis Results

- Can give indication of:
  - Resistance to freeze-thaw
  - Presence of alkali silica reaction-ASR.
  - Other deleterious phenomena
    - Fire Damage
    - Acid Attack
  - Aggregate sources

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Concrete Condition Survey

- Comprehensive review of history.
- Visual examination of the structure
- Laboratory evaluation of the material.